HYDROLOGIC RESOURCE MONITORING PARAMETERS

Lake Levels And Salinity

Brief Description: Lakes are dynamic systems that are sensitive to local climate and to land-use changes in the surrounding landscape [see shoreline position]. Some lakes receive their water mainly from precipitation, some are dominated by drainage runoff, and others are controlled by groundwater systems. On a time scale ranging from days to millennia, the areal extent and depth of water in lakes are indicators of changes in climatic parameters such as precipitation, radiation, temperature, and wind speed. Lake level fluctuations vary with the water balance of the lake and its catchment, and may, in certain cases, reflect changes in shallow groundwater resources.
Especially useful as climatic indicators are lakes without outlets (endorheic), widely distributed in North America. In arid and semi-arid areas, the levels and areas of lakes with outflows are also highly sensitive to weather. Where not directly affected by human actions, lake level fluctuations are excellent indicators of drought conditions. Ephemerally or seasonally-flooded lake basins (playas) are dynamic landforms, the physical character and chemical properties of which reflect local hydrologic changes, and which react sensitively to short-term climate changes (e.g. rate of evaporation).
Fluctuations in lake water salinity (e.g. $CaHCO_3$, $MgHCO_3$, CO_3, $MgSO_4$, $NaSO_4$) also provide an indication of changes in conditions at the surface (climate, inflow/outflow relations) and in shallow groundwater [see sediment sequence and composition; surface water quality].

Significance: The history of fluctuations in lake levels provides a detailed record of climate changes on a scale of ten to a million years. Lakes can also be valuable indicators of near-surface groundwater conditions.

Environment where Applicable: Arid and semi-arid regions, continental mid-latitudes and tropical and subtropical latitudes.

Types Of Monitoring Sites: Shallow and, in particular, saline and hyposaline lakes in sand-rich basins (i.e. where groundwater responds rapidly to climate), ideally located along vegetation and elevation transects that include agricultural and non-agricultural settings.

Method of Measurement: Lake levels are generally measured with shoreline gauges. Areal extent is assessed primarily using successive air photos, supplemented with ground-level surveys, radar altimetry, and satellite images. Salinity is measured by standard analytical means. Past variations in levels and salinity can be recognized by studying old shorelines, lakeside archaeological sites, and the geochemistry, mineralogy, isotopic composition and fossil content of sediment cores. Remains of diatoms, chrysophytes, chironomids, ostracods and other bio-indicators in lake sediments are widely used to infer past lakewater salinity.

Frequency of Measurement: Lake level and lake water composition monthly to annual. Areal extent every 5 years.

Limitations of Data and Monitoring: Limited by availability of gauge data, resolution of photographic and satellite images, and by climatic records for baseline data.

Possible Thresholds: When evaporation exceeds precipitation, as in semi-arid environments, lake area and salinity can change markedly. The utility of lakes as sources of water for human use depends on water availability and quality: thresholds for human health can be rapidly crossed as chemical concentrations (salinity) increase with evaporation.

Key References:

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Neal, J.T., 1965. Geology, mineralogy and hydrology of U.S. playas. US Army Cambridge Research Laboratory, Environmental Research Papers, vol. 96.

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Vance, R.E. & S.A.Wolfe 1996. Geological indicators of water resources in semi-arid environments: Southwestern interior of Canada. In Berger, A.R. & W.J.Iams (eds). Geoindicators: Assessing rapid environmental changes in earth systems:237-250. Rotterdam: A.A. Balkema.

Related Environmental and Geological Issues: Lake levels are important for regional hydrological investigations, and for a wide range of issues concerning lakeshore land use.

Overall Assessment: Monitoring lake extent, depth and salinity provides a convenient and simple guide to changes in climate and hydrological conditions.

Source: This summary of monitoring parameters has been adapted from the Geoindicator Checklist developed by the International Union of Geological Sciences through its Commission on Geological Sciences for Environmental Planning. Geoindicators include 27 earth system processes and phenomena that are liable to change in less than a century in magnitude, direction, or rate to an extent that may be significant for environmental sustainability and ecological health. Geoindicators were developed as tools to assist in integrated assessments of natural environments and ecosystems, as well as for state-of-the-environment reporting. Some general references useful for many geoindicators are listed here:

Berger, A.R. & W.J.Iams (eds.) 1996. Geoindicators: assessing rapid environmental change in earth systems. Rotterdam: Balkema. The scientific and policy background to geoindicators, including the first formal publication of the geoindicator checklist.

Goudie, A. 1990. Geomorphological techniques. Second Edition. London: Allen & Unwin. A comprehensive review of techniques that have been employed in studies of drainage basins, rivers, hillslopes, glaciers and other landforms.

Gregory, K.J. & D.E.Walling (eds) 1987. Human activity and environmental processes. New York: John Wiley. Precipitation; hydrological, coastal and ocean processes; lacustrine systems; slopes and weathering; river channels; permafrost; land subsidence; soil profiles, erosion and conservation; impacts on vegetation and animals; desertification.

Nuhfer, E.B., R.J.Proctor & P.H.Moser 1993. The citizens' guide to geologic hazards. American Institute for Professional Geologists (7828 Vance Drive, Ste 103, Arvada CO 80003, USA). A very useful summary of a wide range of natural hazards.